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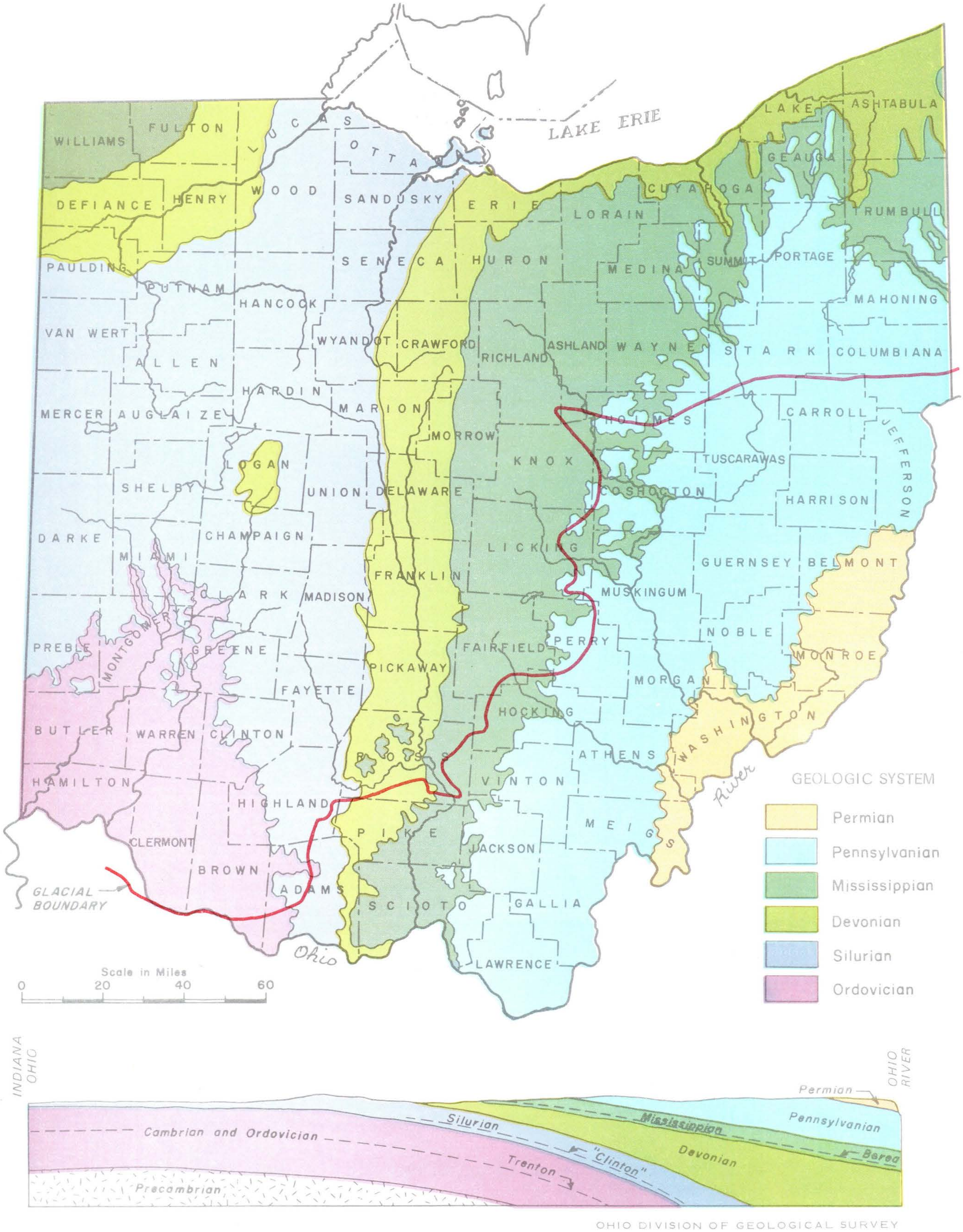
COMPOSITION OF ILLINOIAN AGE

GLACIAL OUTWASH TERRACES

IN THE HOCKING RIVER VALLEY, OHIO

SENIOR THESIS




OHIO DIVISION OF GEOLOGICAL SURVEY

GEOLOGIC MAP AND CROSS SECTION OF OHIO

# COMPOSITION OF ILLINOIAN AGE GLACIAL OUTWASH TERRACES IN THE HOCKING RIVER VALLEY, OHIO

Senior Thesis -- Done in partial fulfillment of the requirements for the degree Bachelor of Science at the Ohio State University

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Under the Advisement of S. E. White

Approved Sidney E. White

Date 15 March 1971

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## ABSTRACT

This report contains the results and analyses of stonecounts, roundness, and sphericity studies of 1894, 25 to 75 millimeter pebbles from Illinoian outwash terraces along the northern end of the Hocking River Valley, Ohio. It concludes that carefully selected lithologic categories may be the most useful indicators for the identification of these terraces, and that roundness determinations may have some potential value, while sphericity determinations appear to be useless for identification purposes.

## PURPOSE AND SCOPE

This report is the result of an investigation of the contents of the Illinoian age glacial outwash terraces in the Hocking River Valley, Ohio. It limits itself to discussion of deposits of this type and age at certain localities within the valley, and more specifically to the lithology, roundness, and shape of pebbles 25 to 75 millimeters along their longest dimension taken from these deposits. This report attempts to define the nature and characteristics of these pebbles, and is intended to add to existing knowledge and to serve as an aid to future investigations of these deposits and the geology of the general area.

## GEOGRAPHY AND GEOLOGY

The Hocking River has its present headwaters on Illinoian and Wisconsin age glacial till deposits north of Lancaster, Ohio. Flowing from thence, the stream leaves the glaciated portion of the Appalachian Plateau province at a point just north of Lancaster and thereafter flows generally southeast through unglaciated hills of Pennsylvanian and Mississippian age sediments[1] running a

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[1]Merrill, 1950.

total distance of some 83 miles to ultimately join with the Ohio River at Hockingsport. Beginning at Lancaster, an extensive system of glacial outwash terraces flanks the river for its entire remaining length. Previous work based almost entirely on the elevations and soil profiles of these deposits[2,3,4] has differentiated them into two of Wisconsin age, one and probably a second of Illinoian age. (See Figure 1) Attempts had previously been made to determine the contents of the Illinoian terraces by means of stonecounts,[3,4] however some of the results seemed inconclusive.

## SAMPLING LOCALITIES AND TECHNIQUES

For purposes of this report a reconnaissance was made of the valley in the autumn of 1970 and of localities in the northern end of the valley, where excavations had been made in material defined above, were carefully examined. Ultimately samples were collected at 4 of these sites. Samples were taken only from freshly worked faces which showed no signs of sliding, slumping, or other mixing of material. Samples of 100 pebbles each were collected

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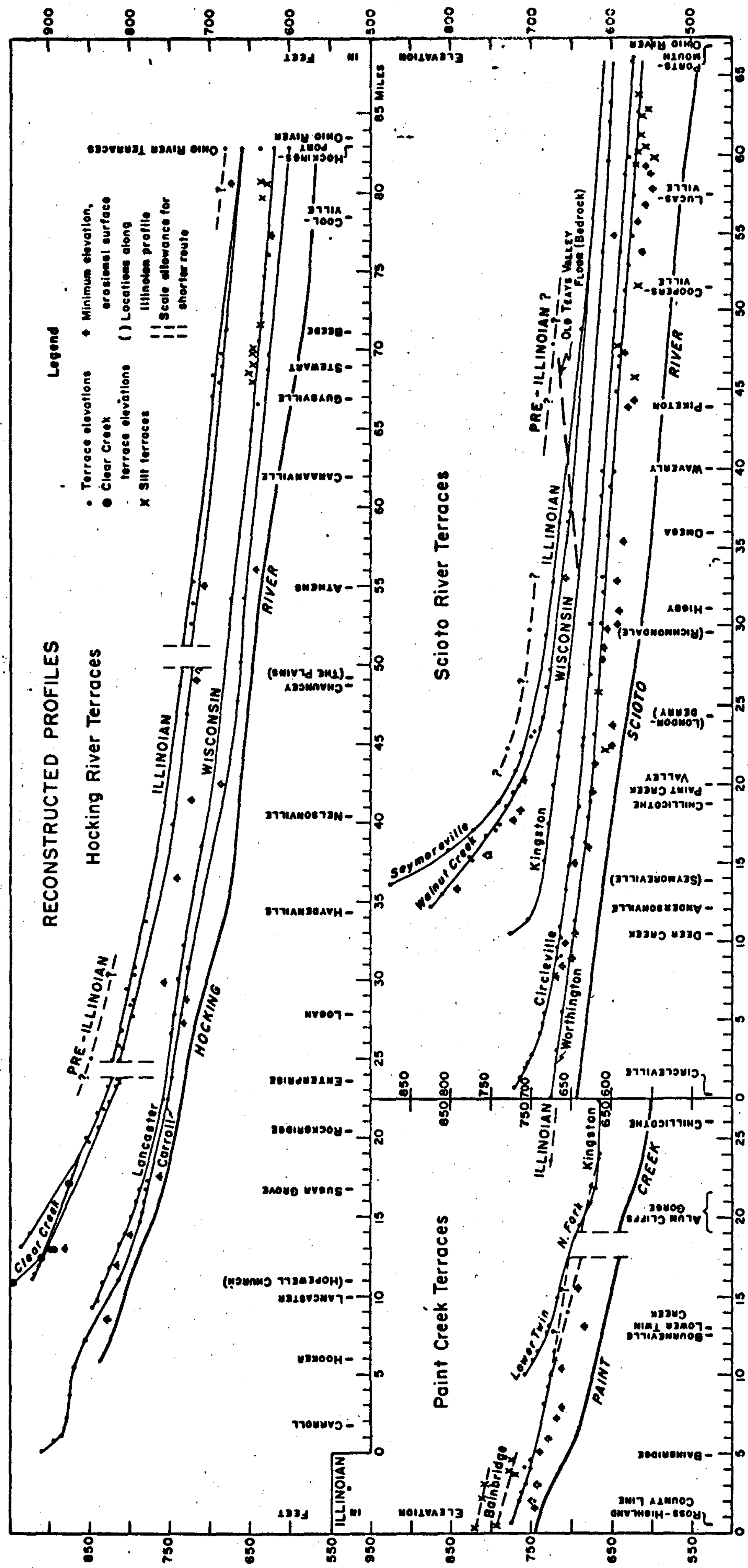
[2] Merrill, 1950.

[3] Kempton, 1956.

[4] Kempton and Goldthwait, 1959.

FIGURE 1




(from Kempton and Goldthwait, 1959)

at vertical intervals as close to 6 feet apart as possible. No attempt was made to avoid taking pebbles from within the soil profile, however beds which had been cemented together by accumulated carbonates, and pebbles with large amounts of finer material cemented to them were avoided whenever possible. A minimum of two samples of 100 pebbles each were collected at each locality.

Locality A is just south of Lancaster on the southwest side of the valley (NW ¼, NW ¼, Sec. 20, T14N, R18W, See Figure 2, Lancaster, Ohio). This was the best and most obvious place to collect samples, as it is a major sand and gravel quarrying operation with excellent exposures of the gravels in question. Thirteen samples, a total of 1295 pebbles, were collected here.

Locality B is located on the south end of a small knoll on the opposite side of the valley from Locality A (NE ¼, NW ¼, Sec. 21, T14N, R18W). The quarrying here is not extensive, and the pit was partially filled with water. Two samples, 200 pebbles, were collected at this site.

Locality C is a very small scale operation at the north end of this same small knoll (NE ¼, SW ¼, Sec. 16, T14N, R18W). The exposure here is almost entirely sand with occasional thin stringers of gravel. Since the sand had slumped and slid rather badly, it was possible to collect only two samples here for a total of 199 pebbles.

Two other localities in this vicinity were also examined. One just north of site A on the same side of the valley had been abandoned and was useless. The second is a major operation, currently in progress on the valley floor midway between and slightly north of Site A and sites B and C. The gravel here is removed from large, water filled pits (See Figure 2) which are totally unsuitable for sample collection.

Two more localities further south in the valley, both near Enterprise (See Figure 3, Logan, Ohio) were also found unuseable. One is a very large sand and gravel quarry which had been abandoned. Although it showed some signs of recent working, the fresh excavations appeared to be in the abandoned stockpiles remaining from the previous operation. The other locality was a nearby road cut. Sample collection was declined here due to the poor condition of the exposure.

The final site where samples were collected is just south of Logan (one mile southeast of Logan on the northeast side of U.S. Route 33). The quarrying operation here is removing material from the top of a terrace remnant. Two samples, 200 pebbles, were collected here. With continued operation, this pit will undoubtedly expose more of the thickness of the gravel and will probably become a more useful collecting site.

## ANALYSIS OF STONECOUNTS

All of the material collected, a total of 1894 pebbles, was used to determine average quantities of selected lithologies present in these gravel beds. Each pebble was cracked open to expose a fresh, unweathered surface, and was sorted according to the following scheme of lithologies:

I. Crystalline (Igneous and Metamorphic) Rocks

- A) Quartzite (including tillite)
- B) Strongly foliated gneiss
- C) Schist
- D) All dark aphanitic igneous and metamorphic rocks (chiefly basalt)
- E) All dark phaneritic igneous and metamorphic rocks, except B) and C) above (chiefly diorite)
- F) All light phaneritic igneous and metamorphic rocks, except B) and C) above (chiefly granite and weakly foliated gneiss)

II. Clastic Rocks and Associates

- A) Clay ironstone
- B) Black shale
- C) All other shale
- D) Gray sandstone (usually with muscovite)

E) Brown sandstone (often heavily cemented with hematite), and rounded quartz pebbles from local conglomerates

III. Carbonate and Associated Rocks, plus all other undifferentiated material

A) Chert and flint

B) Black limestone

C) All other limestone

D) Brown, porous dolomite (distinct internal cavities)

E) Banded dolomite (Gray to Gray-Brown, distinct parallel dark gray bands)

F) All other dolomite and all other undifferentiated or unidentifiable sediments

This scheme was used for several reasons. First, it permits rapid, sight identification of almost all lithologies and hence, promotes convenient processing of very large quantities of material. Second, all stonecounts, unless conducted with meticulous care, contain some amount of uncertainty in the identification of the rocks actually present. It is hoped that categorizing the rocks in this manner serves to minimize uncertainty and to treat what uncertainty does occur in such a way as to decrease its effects. The chief difference between this scheme and somewhat more conventional ones is the inclusion of a large quantity of "uncertain" material in category III-F. In addition to the previously mentioned reasons, this category was created to handle materials of similar appearance, chemical, and mechanical properties. This removes any confusion arising from trying to rapidly sort these very similar rock types, and furthermore renders the stonecount data more amenable to comparison with roundness and sphericity data elsewhere in this report. All future users of this stonecount data should bear firmly in mind that it has been obtained in a slight but significantly different manner.

The results of the stonecounts are summarized in Table 1. Nothing especially unusual or dramatic was discovered. As had been expected, all of the limestone and some of the dolomite was missing from samples collected within the soil profile. In cases where this effect was noted there was almost always a compensatory increase in the amount of chert present, but the average carbonate content of these samples still fell below average in spite of this effect. In samples taken from sites B and C the percentages of black limestone and undifferentiated limestone are approximately equal, the percentage of black limestone being higher, and all other limestone being lower than their respective averages. Although this may only be a coincidence, there is the possibility that this may represent a genuine difference between the two proposed

TABLE 1

Summary of Stonecount Data

| Lithologic Category | Locality A-1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | B-1 | 2 | C-1 | 2 | D-1 | 2 | High | Low | Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I) Crystalline Rocks | | | | | | | | | | | | | | | | | | | | | | | |
| A) Quartzite | 11 | 5 | 12 | 7 | 5 | 8 | 1 | 12 | 3 | 5 | 6 | 2 | 4 | 10 | 9 | 9 | 5 | 12 | 6 | 12 | 1 | 11 | 6.9 |
| B) Gneiss | 3 | 0 | 1 | 3 | 3 | 0 | 1 | 2 | 2 | 4 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 0 | 4 | 1.5 |
| C) Schist | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0.1 |
| D) Dark Aphanitic | 6 | 0 | 5 | 7 | 1 | 4 | 4 | 3 | 3 | 6 | 1 | 1 | 0 | 8 | 2 | 3 | 2 | 4 | 4 | 8 | 0 | 8 | 3.4 |
| E) Dark Phaneritic | 0 | 1 | 2 | 2 | 4 | 2 | 2 | 2 | 8 | 4 | 2 | 1 | 1 | 5 | 0 | 3 | 1 | 0 | 3 | 8 | 0 | 8 | 2.3 |
| F) Light Phaneritic | 2 | 4 | 4 | 5 | 7 | 4 | 1 | 5 | 0 | 1 | 4 | 3 | 3 | 5 | 4 | 2 | 3 | 3 | 8 | 8 | 0 | 8 | 3.6 |
| Total | 22 | 11 | 24 | 23 | 20 | 18 | 9 | 24 | 16 | 22 | 15 | 7 | 8 | 28 | 15 | 18 | 12 | 21 | 24 | 28 | 7 | 21 | 17.8 |
| II) Clastic Rocks | | | | | | | | | | | | | | | | | | | | | | | |
| A) Clay Ironstone | 7 | 2 | 6 | 0 | 1 | 3 | 4 | 3 | 1 | 2 | 6 | 3 | 2 | 5 | 3 | 2 | 4 | 3 | 3 | 7 | 0 | 7 | 3.5 |
| B) Black Shale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0.2 |
| C) Other Shale | 0 | 3 | 1 | 1 | 4 | 2 | 1 | 1 | 2 | 1 | 2 | 5 | 3 | 1 | 3 | 1 | 6 | 0 | 0 | 6 | 0 | 6 | 2.1 |
| D) Gray Sandstone | 10 | 13 | 9 | 3 | 2 | 5 | 5 | 0 | 1 | 5 | 2 | 11 | 0 | 5 | 11 | 6 | 13 | 11 | 12 | 13 | 0 | 13 | 6.5 |
| E) Brown Sandstone | 17 | 18 | 11 | 14 | 16 | 8 | 9 | 7 | 17 | 7 | 6 | 10 | 4 | 9 | 5 | 9 | 10 | 17 | 12 | 18 | 5 | 13 | 11.9 |
| Total | 34 | 37 | 26 | 18 | 23 | 18 | 19 | 11 | 22 | 15 | 16 | 29 | 10 | 20 | 23 | 20 | 33 | 31 | 27 | 37 | 10 | 27 | 22.5 |
| III) Carbonate and Undifferentiated | | | | | | | | | | | | | | | | | | | | | | | |
| A) Chert | 16 | 28 | 21 | 9 | 20 | 6 | 9 | 5 | 4 | 9 | 8 | 15 | 7 | 5 | 8 | 7 | 16 | 4 | 18 | 28 | 4 | 24 | 11.3 |
| B) Black Limestone | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 6 | 5 | 5 | 4 | 2 | 7 | 7 | 9 | 10 | 3 | 0 | 0 | 10 | 0 | 10 | 3.5 |
| C) Other Limestone | 0 | 0 | 0 | 3 | 0 | 15 | 14 | 12 | 24 | 10 | 15 | 11 | 26 | 6 | 9 | 7 | 3 | 0 | 0 | 26 | 0 | 26 | 8.0 |
| D) Porous Dolomite | 0 | 2 | 0 | 0 | 0 | 3 | 3 | 7 | 0 | 6 | 6 | 1 | 6 | 3 | 3 | 2 | 2 | 1 | 1 | 7 | 0 | 7 | 2.4 |
| E) Banded Dolomite | 0 | 0 | 0 | 5 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 5 | 0 | 5 | 0.8 |
| F) Remainder | 29 | 32 | 30 | 42 | 38 | 35 | 41 | 33 | 28 | 32 | 36 | 34 | 35 | 31 | 32 | 36 | 30 | 43 | 30 | 43 | 28 | 15 | 34.0 |
| Total | 45 | 52 | 51 | 59 | 58 | 64 | 72 | 65 | 62 | 62 | 70 | 64 | 82 | 52 | 63 | 61 | 55 | 48 | 49 | 82 | 45 | 37 | 59.7 |

(All data originally calculated to three significant figures before inclusion in this table)

TABLE 1

(continued)

Summary of Stonecount Data

| | I | II | III |
|---|---|---|---|
| Locality A | 16.9 | 21.1 | 62.0 |
| B | 21.5 | 21.5 | 57.0 |
| C | 15.1 | 26.6 | 58.2 |
| D | 22.5 | 27.0 | 48.5 |
| Overall Mean | 17.8 | 22.5 | 59.7 |
| Standard Deviation | 6.22 | 7.24 | 8.70 |
| Mean Absolute Deviation | 5.26 | 6.03 | 7.17 |

## Brief Explanation of Statistical Methods

For those who may not be familiar with some of the statistical operations used in the preparation of this report a brief explanation is in order. Measurements of pebbles in each sample have in all cases been averaged. When a particular sample (e.g. "B-2") is listed, the number given is the average (mean) value of all 50 or 100 pebbles measured. The "overall mean" is the average of the mean values of all nineteen samples. The mean absolute deviation is the average value by which any sample differs from the overall mean. The standard deviation is the square root of the average of the squares of the deviations of the individual samples from the overall mean.

levels of Illinoian outwash. Examination of the Lancaster map (Figure 1), does not rule out this hypothesis. This phenomenon will certainly bear further examination. There are also some variations in the quantities of Gray and Brown sandstone present among the samples from all four localities, however no distinct trends are readily apparent in this case, and it is assumed that these and all other variations are random, except as noted above.

## Analysis of Roundness

Roundness, for purposes of this report, may be defined as the relationship between the curvature of the corners and edges of a pebble and the overall curvature of the pebble as a whole.[5] Defined in this way, roundness is a measure of the surface texture of a pebble. A total of 900 pebbles were examined by holding each one so its long and intermediate axes were perpendicular to the line of sight and comparing it to a chart (Figure 4) showing typical silhouettes representing a range of nine roundness values from 0.1, very rough and angular, to 0.9, very smooth and even.

The surface which develops on a particular pebble depends, of course, on a wide range of physical and chemical

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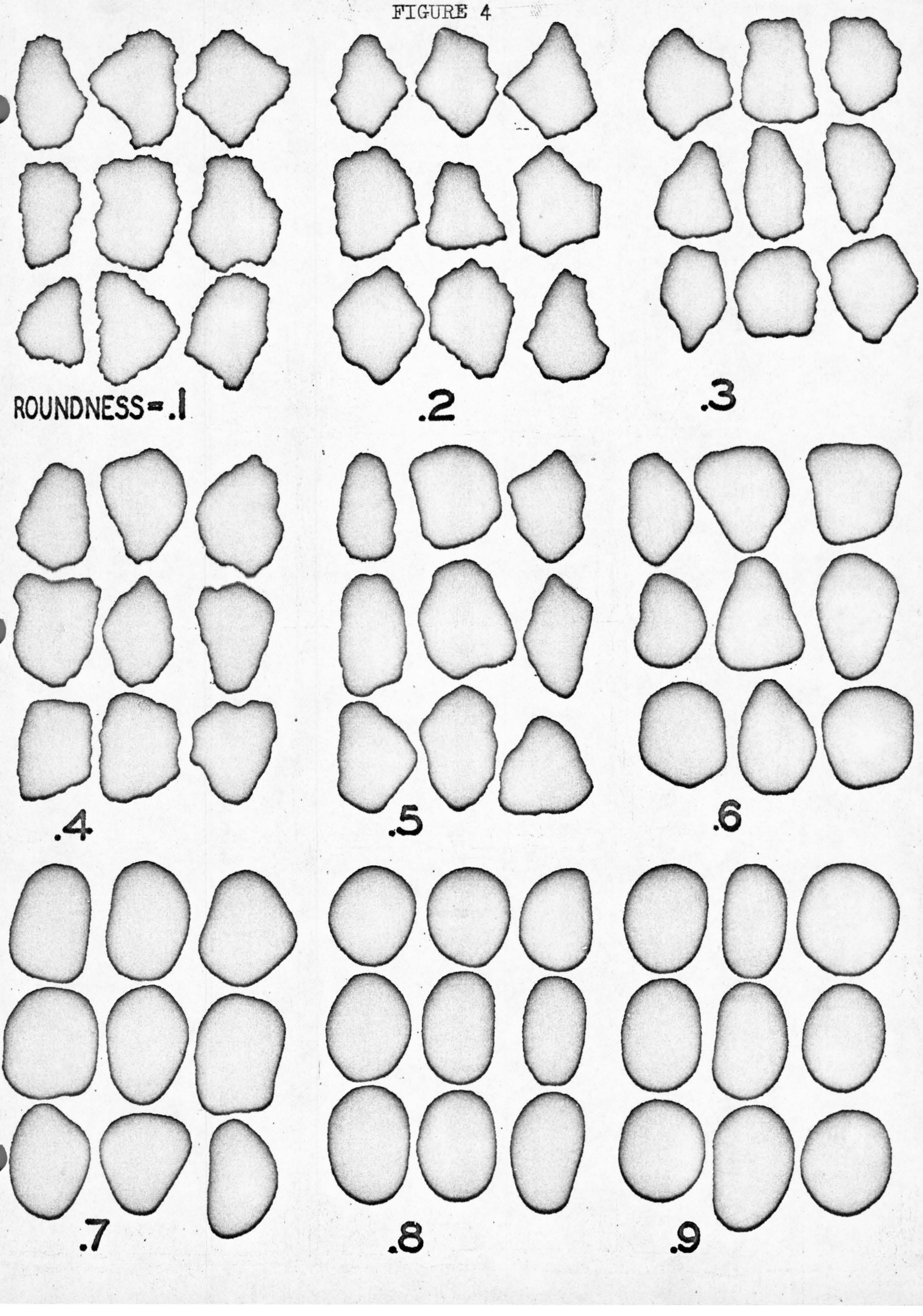
[5] Krumbein, 1941.

FIGURE 4



factors, both within the pebble, and in its environment. In the case of some of the pebbles studied for this report, chemical processes acting on the pebbles after their deposition in the terraces have played a major part in the evolution of their surfaces. Leaching, etching, and chemical weathering have been significant factors in the history of shallow samples. Deeper samples have been subject to accumulation of carbonates on their surfaces, often to the extent of cementing large beds of gravel into a tough, conglomeratic rock which is in itself characteristic of these particular terraces. Although attempts were made to avoid pebbles with material cemented to them, this effect has undoubtedly influenced the overall roundness determinations.

The results of the roundness examinations are summarized in Table 2. The range of values seems rather large to represent errors in estimation of individual pebbles, and the high standard and mean absolute deviations reinforces the conclusion that this variation is an actual characteristic of the samples. The only major trend which is clearly evident appears in the averages for samples from site A, where the mean roundness seems to increase with depth (See Figure 5). The small number of averages for localities B, C, and D makes any other reasonable generalizations impossible.

TABLE 2

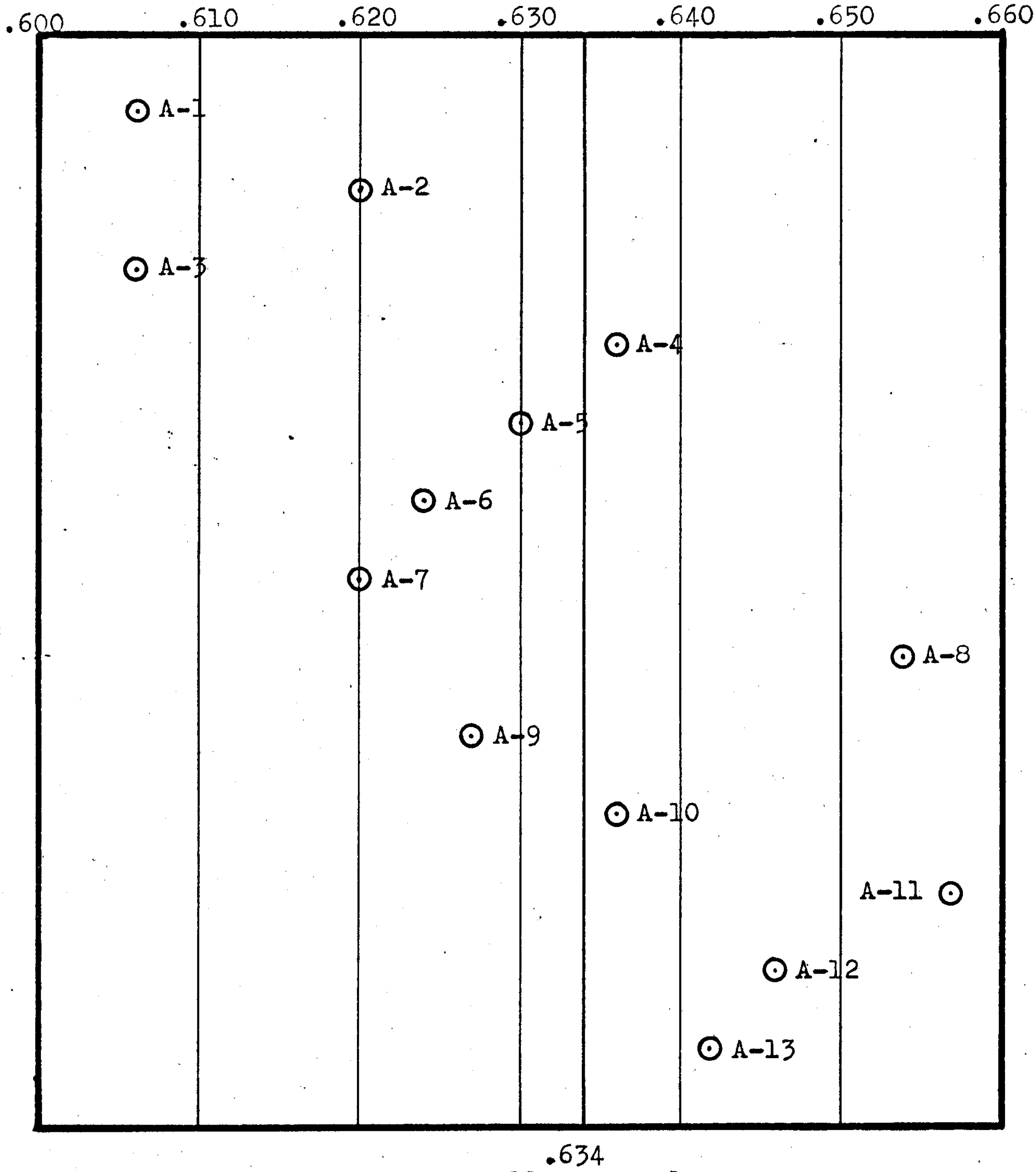
Summary of Roundness Data

| Locality | Mean Roundness |
|---|---|
| A-1 | .606 |
| 2 | .620 |
| 3 | .606 |
| 4 | .636 |
| 5 | .630 |
| 6 | .624 |
| 7 | .620 |
| 8 | .654 |
| 9 | .632 |
| 10 | .636 |
| 11 | .656 |
| 12 | .646 |
| 13 | .642 |
| Mean | .632 |
| B-1 | .624 |
| 2 | .652 |
| Mean | .638 |
| C-1 | .626 |
| 2 | .658 |
| Mean | .642 |
| D-1 | .646 |
| 2 | .628 |
| Mean | .637 |

| Overall | |
|---|---|
| Range | .052 |
| High | .658 |
| Low | .606 |
| Mean | .634 |
| Median | .632 |
| Standard Deviation | .015 |
| Mean Absolute Deviation | .013 |

FIGURE 5

Plot of mean roundness
at locality A.




overall mean value
for 19 samples

(Note: all samples are numbered
by increasing depth)

Comparison of roundness data with stonecount data indicates that any relationship between average roundness of a particular sample, and its lithologic composition, is either absent or highly obscured. This is in agreement with the role of chemical processes as discussed previously in this section.

## Analysis of Sphericity

Nine hundred pebbles were also examined to determine their average shape.[6] Each pebble was measured in millimeters with a simple caliper device, starting with the longest (or "a") dimension, following with the intermediate ("b") and short ("c") dimensions in that order. Care was taken to insure that all three measurements were made along three mutually perpendicular axes. The ratios of the short to the intermediate (c/b) and the intermediate to the long (b/a) were then calculated (See Table 3). This computation permits each pebble to be considered as a smooth ellipsoidal solid, regardless of its corners and edges. The values of b/a and c/b can be plotted on a graph and compared. This has been done in Figure 6.

It is noteworthy that the mean b/a values for localities B and C, and the c/b value for locality D all fall outside the standard deviations for those respective

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[6]Krumbein, 1941.

TABLE 3

Summary of Sphericity Data

| Locality | b/a | c/b | a | b | c |
|---|---|---|---|---|---|
| A-1 | .765 | .621 | 38.4 | 26.9 | 17.6 |
| 2 | .730 | .681 | 40.4 | 29.7 | 20.0 |
| 3 | .694 | .690 | 40.7 | 29.1 | 20.3 |
| 4 | .781 | .636 | 40.7 | 31.3 | 19.5 |
| 5 | .753 | .631 | 39.4 | 29.2 | 18.0 |
| 6 | .766 | .683 | 45.9 | 31.0 | 21.0 |
| 7 | .749 | .652 | 38.7 | 29.5 | 18.1 |
| 8 | .739 | .632 | 37.8 | 27.8 | 17.1 |
| 9 | .768 | .635 | 39.2 | 33.1 | 19.1 |
| 10 | .777 | .653 | 40.3 | 31.2 | 20.2 |
| 11 | .750 | .601 | 36.3 | 27.8 | 16.8 |
| 12 | .711 | .638 | 36.5 | 25.5 | 15.7 |
| 13 | .733 | .614 | 37.2 | 27.5 | 17.2 |
| Mean | .747 | .644 | 39.4 | 29.4 | 18.5 |
| B-1 | .771 | .662 | 39.9 | 30.8 | 18.2 |
| 2 | .786 | .710 | 38.2 | 28.9 | 20.9 |
| Mean | .780 | .665 | 39.1 | 29.8 | 19.6 |
| C-1 | .595 | .665 | 31.0 | 30.4 | 17.7 |
| 2 | .736 | .686 | 55.5 | 24.3 | 14.7 |
| Mean | .644 | .675 | 43.2 | 27.4 | 16.2 |
| D-1 | .746 | .595 | 38.2 | 29.1 | 16.8 |
| 2 | .710 | .582 | 44.1 | 31.5 | 18.4 |
| Mean | .730 | .590 | 41.1 | 30.3 | 17.6 |

(continued)

TABLE 3

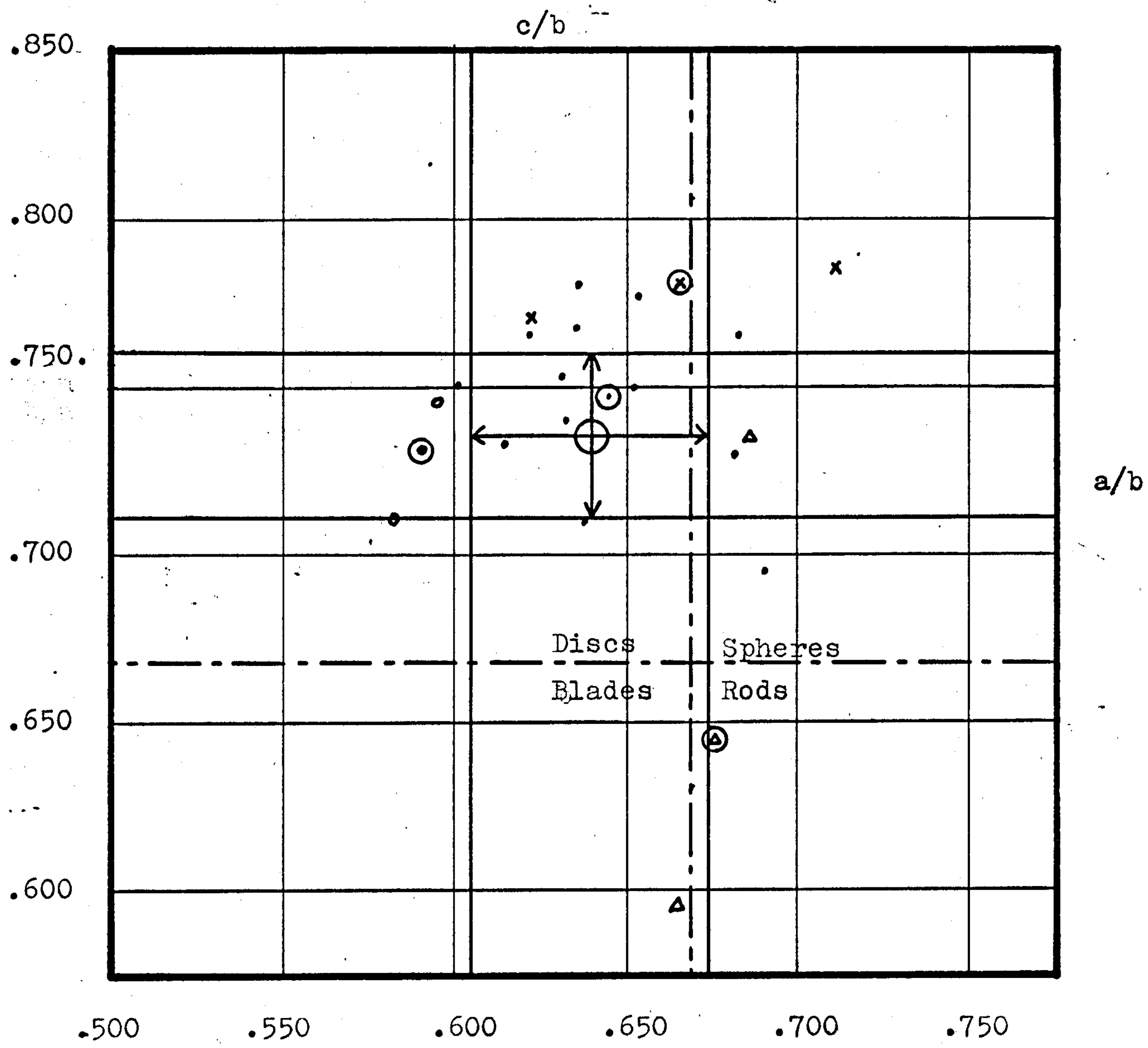
Sphericity Data
(continued)

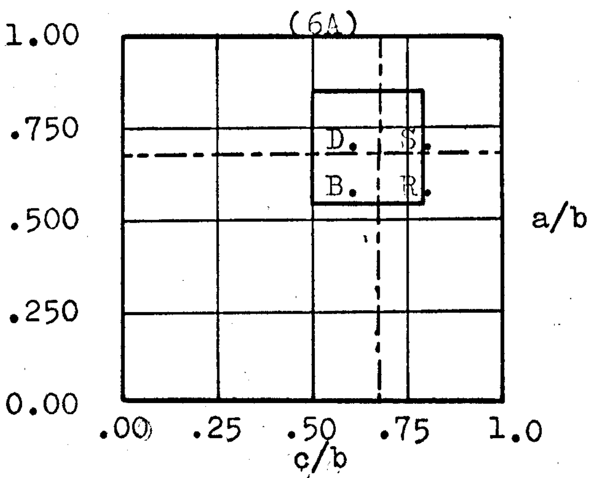
| | b/a | c/b | a | b | c |
|---|---|---|---|---|---|
| Overall mean 19 samples | .736 | .644 | 38.9 | 29.4 | 18.3 |
| High | .786 | .710 | 55.5 | 33.1 | 20.9 |
| Low | .595 | .582 | 31.0 | 24.3 | 14.7 |
| Range | .191 | .128 | 24.5 | 8.8 | 6.2 |
| Standard Deviation | .025 | .034 | | | |
| Mean Absolute Deviation | .025 | .029 | | | |

ratios. The cause of this dispersion is a puzzle. It is reasonable, and has been empirically shown, that the lithology of pebbles influences their shape. Bedded sediments tend to produce pebbles with high a and b dimensions and a small c dimension, thus producing moderate to high b/a values and small c/b values, causing these rock types to cluster along the upper edge of a graph such as Figure 6-A. Likewise, carbonates, and uniform clastic rocks similar to them, tend to fall across the middle of such a plot, while some igneous and many metamorphic species tend toward the lower side. All attempts to relate the variations of the mean sphericity points for locations B, C, and D to the schema discussed above have proved frustrating and futile. The same may be said of attempted correlations with the roundness data. It is, of course, possible that this dispersion is a random error arising from the relatively small number of pebbles analysed from sites B, C, and D. In any event, the evenness with which the anomalous points are distributed about the mean certainly seems to suggest that some sort of random process is involved. One reasonable hypothesis would postulate some type of sorting by shape during the deposition of these sediments. There are certainly many other possible explanations. Further research is definitely called for.

FIGURES 6, 6A

Plots of Sphericity Data




=A
=B
=C
=D
indicates mean value

Arrows indicate standard deviation.

## SUMMARY AND CONCLUSIONS

The following conclusions have been reached by the author:

1. It is believed that sufficient samples were taken from both proposed levels of Illinoian outwash, and that the techniques of this investigation are not able, with perhaps one isolated exception, to distinguish between them.

2. The author strongly believes that future stone-counts should be conducted in a manner which sorts an appreciable percentage of the sample into a number of narrowly defined lithologic categories, perhaps similar to the scheme used in this report.

3. The most reliable looking, individual lithologic indicators seem to be the brown sandstone and the quartzite content of these terraces. Both of these rock types were always present in all the samples, and both of them vary only within relatively small limits. Chert and Black limestone, outside of soil profiles, are potentially very useful. Taken together, these four rock types account for approximately one third of the total lithology, and when present in the quantities outlined in this report, may be considered to positively identify the Illinoian terraces.

4. Roundness data, though somewhat variable, also falls within a small enough range to be potentially of value. The usefulness of such data will depend on whether

or not the range of values is sufficiently different among the deposits in the valley to permit the various deposits to be distinguished. Further research will be needed to determine the ultimate practicability and extent to which roundness determinations will be useable.

5. Shape analysis data is not likely to be of much use in identification of these terraces. The wide variations among the various localities cannot be correlated to either stonecount or roundness data, and are apparently due to unknown random processes. Until the reasons for the dispersion of the sphericity data are known and understood, pebble shape analysis for the purpose of identifying these terraces will remain a poor use of time and effort.

6. Finally, the author wishes to express his opinion that the choice of soil development and physiography for the earlier surveys of this area[7,8] was a wise and very sound one, and that the data in this report may ultimately prove most useful in making positive identifications at localities where these other methods cannot be successfully employed.

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[7]Kempton, 1956.

[8]Kempton and Goldthwait, 1959.

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For general reference see also:

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